STATE OF CALIFORNIA
Department of Transportation
Specification for
Sprayable Thermoplastic Traffic Striping Material, White and Lead-Free Yellow

1.0 SCOPE

This specification covers a hot-melt, retroreflective, thermoplastic traffic marking material that is suitable for producing durable traffic stripes and pavement markings on Portland cement concrete or asphalt concrete pavements. This material is heated and applied to road surfaces in a molten state using a mechanical applicator. While still hot, reflectorizing glass beads are applied to the surface of the applied thermoplastic striping material. Upon cooling to normal pavement temperatures this material shall produce durable, adherent, retroreflective traffic stripes and pavement markings that are capable of resisting deformation by traffic.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods and standards in effect on the opening date of the Invitation for Bid form a part of this specification where referenced.

- California Test Methods (CTM); No. 423 and No. 660 (latest revision).
- California Department of Transportation, Standard Specifications, 2015.
- Federal Standard Designation: No. 595b, color #33538.
- U.S. Environmental Protection Agency (EPA), SW-846, Methods 3052 and 6010B.
- American Association of State Highway and Transportation Officials, (AASHTO) Designation: M 247.
- American Society for Testing and Materials, (ASTM) Designations; D 476, D 2794, D 3335, D 3718, D 5380, D 5381, D 6628, E 11, E 28, E 313, E 1621, E 1710, and G 155.
- Commission International de l'Eclairage (C.I.E.) 1931 Chromaticity Diagram.
- California Code of Regulations: Title 22.

3.0 REQUIREMENTS

3.1 Composition:

The thermoplastic material shall be composed of 100% solids. The binder shall consist of hydrocarbon or alkyd thermoplastic resins which are homogeneously blended together with all necessary prime pigments, fillers, glass beads and additives to produce a traffic striping material that meets the requirements as specified herein. The type of resin binder (alkyd or hydrocarbon) may be specified in the purchase order. All thermoplastic material shall be free from; lead, chromium, cadmium, barium and other toxic metals.

3.1.1 White Material:

White thermoplastic shall contain a minimum of 10% (by weight) titanium dioxide pigment meeting ASTM D476 Type II (Rutile). The titanium dioxide content will be determined using ASTM Designations; D 5380 and E 1621. White thermoplastic must meet the Retroreflectivity requirement when applied with drop-on glass beads.

This specification cancels and supercedes; specification #PTH-02SPRAY (March 2009, February 2009, February 2006 and October 2002), specification #PTH-392B (August, 1996) and specification #PTH-392A (April, 1993).

3.1.2 Lead-Free Yellow Material:
Lead-Free (L/F) yellow thermoplastic shall contain proper amounts of C.I. Pigment Yellow 83 (opaque version) and titanium dioxide (Rutile) to produce a yellow material that has a weather-fast and heat stable yellow color which meets the; Yellow Color, Reflectance, Color Stability (Accelerated Weathering) and Retroreflectivity requirements as stated herein. Other pigments may be added to achieve these color requirements. The L/F yellow thermoplastic material shall appear yellow during both daytime and nighttime conditions when applied with drop-on beads.

3.1.3 Other Ingredients:
The remainder of the thermoplastic composition shall be determined by the manufacturer - within the constraints of the requirements below. It shall be the manufacturer's responsibility to produce a thermoplastic material containing the necessary plasticizers, antioxidants, and other additives so that the thermoplastic will retain its color, viscosity and all other properties as specified herein. In addition to being essentially lead and chromium free, the thermoplastic shall not contain any hazardous materials at levels that would cause the thermoplastic to be classified as a hazardous waste under Title 22, Division 4, section 66261.20 of the California Code of Regulations.

3.2 **Form:**
The thermoplastic material shall be supplied in either block or granular form as requested in the purchase order.

3.3 **Application Type/Viscosity:**
The thermoplastic material shall be suitable for air-atomized spray application at temperatures between 177°C and 204°C. The viscosity of the molten material at these temperatures shall be suitable for applying thermoplastic traffic stripes that are ~1.0-mm thick.

3.4 **Characteristics of the Finished Thermoplastic:**
Use California Test Method No. 423 (CTM 423) unless otherwise specified.

		White	L/F Yellow
3.4.1	Glass Bead Content, intermixed, percent by weight, CTM 423 (Part 4). Glass beads shall meet AASHTO Designation: M 247 Type I, except the glass beads shall not contain more than 200 ppm (total) arsenic, 200 ppm (total) antimony, nor more than 200 ppm (total) lead, when tested according to EPA Methods 3052 and 6010B. Other suitable x-ray fluorescence spectrometry analysis methods may be used to screen samples of glass beads for arsenic, antimony and lead content.	30-35	30-35

		White	L/F Yellow
3.4.2	Binder Content, percent by weight, minimum. CTM 423 (Part 3).	25	25

		White	L/F Yellow
3.4.3	Inert Fillers, insoluble in hydrochloric acid, percent passing a sieve with openings of 150μm, percent by weight, minimum, ASTM Designation: E 11.	100	100
		White	L/F Yellow
3.4.4	Titanium Dioxide (Rutile) Pigment meeting ASTM Designation D476 Type II. Analyze titanium dioxide content using ASTM Designation: D 5380 and E 1621 percent by weight, minimum.	10	---
		White	L/F Yellow
3.4.5	Specific Gravity, maximum, CTM 423 (Part 5).	2.10	2.10
		White	L/F Yellow
3.4.6	Ring and Ball Softening Point, CTM 423 (Part 6), ASTM Designation: E 28.	90°-121°C	90°-121°C

3.4.7 **Perform the remaining tests on the material after 4 hours heating** with stirring at 191 ± 2°C. This 4-hour period includes time required (~1 hr.) for melting and temperature stabilization of the 6 kg. sample.

		White	L/F Yellow
3.4.7.1	Tensile Bond Strength to an unprimed abrasive blasted Portland cement concrete brick, 1.6 mm thick film draw down at 191°C, tested at 25 ± 2°C, MPa, minimum, CTM 423 (Part 7).	1.24 MPa	1.24 MPa
		White	L/F Yellow
3.4.7.2	Brookfield Thermosel Viscosity, Spindle SC4-27, 20 rpm at 191°C, Pa•s, CTM 423 (Part 8).	<2.0	<2.0
		White	L/F Yellow
3.4.7.3	Impact Resistance, 1.6 mm thick film draw down at 191°C on an unprimed abrasive blasted Portland cement concrete brick, male indentor 15.9 mm diameter, no female die. Test at 25 ± 2°C, kilogram force•meter, with no; chips, cracks or bond loss, minimum CTM 423 (Part 9), ASTM Designation D 2794.	0.58	0.58
		White	L/F Yellow
3.4.7.4	Daylight Luminous Reflectance CTM 423 (Part 11) except use a BYK-Gardner "Color-Guide" Spectrophotometer. Follow the manufacturer's instructions to obtain the	82 Minimum	42 to 59

Reflectance or "Y" value. Set-up the spectro-photometer for 2° Observer and Illuminant "C" measurement conditions.

		White	L/F Yellow
3.4.7.5	Yellow Color, shall match Federal Standard Designation: No. 595b, color #33538 and shall lie within the following chromaticity limits "colorbox" defined by plotting the following four (x,y) pairs on a C.I.E. 1931 Chromaticity diagram; (x1,y1) = (0.5125, 0.4866) (x2,y2) = (0.4865, 0.4647) (x3,y3) = (0.5000, 0.4416) (x4,y4) = (0.5348, 0.4646) Reflectance (Y) shall be between 42 and 59. Measurement conditions = 2°Observer/illuminant "C". Tested according to CTM 423 (Part 10) except use a BYK-Gardner "Color-Guide" Spectrophotometer to measure the color. Follow the manufacturer's instructions to obtain the (x,y) chromaticity coordinates. See attached Yellow Color graph.	---	Pass

		White	L/F Yellow
3.4.7.6	Yellowness Index, maximum Follow CTM 423 (Part 11) except use a BYK-Gardner "Color-Guide" Spectrophotometer to measure the Yellowness Index of the white thermoplastic using the ASTM Designation: E313 mode.	8	---

3.4.7.7 Color Stability after Accelerated Weathering, ASTM Designation: G 155, Table X3.1, Cycle 1, 500 hours total exposure time. Prepare sample by dipping a sheet aluminum panel into the molten thermoplastic and removing it to obtain a 1.0 to 2.0mm coating thickness of thermoplastic on the panel. Place the panel in the weathering apparatus for 500 hrs. After accelerated weathering, measure the Yellow Color or Yellowness Index as in section 3.4.7.5 or 3.4.7.6 above. Material must meet the color stability requirements below after this exposure.

		White	L/F Yellow
White -	Yellowness Index, maximum	20	---
Yellow -	Measured chromaticity coordinates must fall within a "colorbox" defined by plotting the following four (x,y) pairs on a C.I.E. 1931 Chromaticity diagram.	---	Pass

See attached Yellow Color graph.
(x1, y1) = (0.5125, 0.4866)
(x2, y2) = (0.4650, 0.4466)
(x3, y3) = (0.4750, 0.4251)
(x4, y4) = (0.5348, 0.4646)

		White	L/F Yellow
3.4.7.8	Hardness, Shore A-2 Durometer, measure according to CTM 423 (Part 12) except condition the sample for 2 hrs. in a 46.1°C water bath before measuring the Hardness. The Durometer is also conditioned at 46.1°C in a forced air oven. Remove the sample from the water bath and quickly place the Durometer on the sample while starting a stopwatch. Record the Hardness after 15 seconds. The total weight of the Durometer shall be 2000 grams.	20 to 65	20 to 65

		White	L/F Yellow
3.4.7.9	Abrasion Test Use 400 g of graded glass beads between 600 and 850 μm diameter and an air pressure of 152 kPa to sandblast the sample in 4 different areas according to CTM 423 (Part 14), total weight loss, grams, maximum.	10	10

		White	L/F Yellow
3.4.7.10	Lead, mg/kg in thermoplastic, maximum, ASTM D3335	20	20

		White	L/F Yellow
3.4.7.11	Chromium, mg/kg in thermoplastic, maximum, ASTM D3718	5	5

		White	L/F Yellow
3.4.7.12	Initial Retroreflectivity of applied thermoplastic striping (with beads), $mcd \bullet m^{-2} \bullet lx^{-1}$, minimum	250	175

The thermoplastic shall produce delineation and pavement markings that have the required minimum level of retroreflectivity when applied with drop-on beads. Drop-on glass beads shall be uniformly applied at a minimum rate of 4-kg of beads per 10 square meters of thermoplastic. The retroreflectivity shall be measured as specified in ASTM E 1710.

3.4.7.13 Color after Application

The daytime color of the applied white and yellow thermoplastic traffic stripes and pavement markings (with drop-on beads) shall meet the color requirements in section 3.4.7.7 (Color Stability after Accelerated Weathering). The color shall be measured within 60 days of application using a portable BYK-Gardner "Color-Guide" Spectrophotometer (see sections 3.4.7.5 and 3.4.7.6).

3.5 Other Requirements:

3.5.1 Melting and Applicability:

Bags of thermoplastic shall not harden during shipment and storage to the point where the material must be broken-up with tools before loading into the melter. When heated, the thermoplastic material shall completely melt to a homogeneous fluid with satisfactory application qualities and shall be free of debris. The molten thermoplastic material shall be readily applied at temperatures between 177°C and 204°C. Upon application to the pavement, the thermoplastic material shall be sufficiently tack-free to carry traffic; in not more than 2 minutes when the pavement surface temperature is 16°C, and in not more than 10 minutes when the pavement surface temperature is 54°C.

3.5.2 Workmanship:

The materials' ingredients (resins, pigments, glass beads, fillers and additives) shall be homogeneously blended. The finished product shall be uniform from bag to bag. The melted thermoplastic material shall have no indications of resin separation or incompatibility of resins when melted or after cooling. The material shall be free from all; dirt, water, foreign matter, and other deleterious substances capable of clogging; screens, valves, pumps and other striping apparatus. The thermoplastic material shall be of such composition that it will not bleed, stain, or discolor when applied to pavements.

3.5.3 Shelf Life:

The material shall maintain the requirements of this specification for a minimum period of one (1) year from the date of manufacture. Any materials failing to do so shall be replaced at the expense of the manufacturer. Ordered thermoplastic shall be no more than 120 days old (based on date of manufacture) upon delivery to a Department of Transportation Maintenance facility. The date of manufacture shall be clearly marked on each bag of thermoplastic.

3.5.4 Air Pollution Compliance:

This material shall comply with all applicable air pollution control rules and regulations. The thermoplastic material shall not emit fumes that are toxic or injurious to persons or property when it is heated to application temperature. The material shall not emit excessive smoke during heating or application.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection and Sampling:

All thermoplastic material intended for use by the California Department of Transportation (the Department) must be tested and approved by the Transportation Laboratory **before** shipment. Manufacturers shall take two (duplicate) 6 kg. representative samples of each lot of thermoplastic and ship the samples to the Transportation Laboratory for testing. The address of the Transportation Laboratory is listed in section 6.4.

A lot shall consist of a batch or consecutive batches of thermoplastic manufactured on the same day using the same formulation. A batch shall be that amount of thermoplastic that was manufactured and packaged in a single operation. Thermoplastic from the same lot shall be palletized, shrink-wrapped, labeled with the manufacturer's lot and batch numbers (on each

pallet) and batch number (on each bag) and stored in a common area to facilitate random sampling of the entire lot by the Inspector. A lot shall be more than 900 kg and shall be less than 20,000 kg. of thermoplastic.

Manufacturers must submit the following information along with the two representative 6 kg samples of each lot for testing.

1. State Specification number (#PTH-02SPRAY (November 2016)).
2. Manufacturer's Product number
3. Color; (White or Lead-Free Yellow) and kgs. represented by samples.
4. Identification numbers of batches comprising the lot, and lot number.
5. Date of manufacture.
6. Form (block or granular).
7. Viscosity (Sprayable)
8. Binder Type (hydrocarbon or alkyd).
9. Sampling method (splitting, thieving, quartering, random bag, etc.).
10. Purchase Order or Contract number.

A manufacturer's test report shall also be included with the representative duplicate samples of each lot sent to the Transportation Laboratory. The following information shall be included in the manufacturer's test report:

- Brookfield Thermosel Viscosity @ 191°C
- Hardness
- Binder Content
- Glass Bead Content
- Daylight Luminous Reflectance
- Yellow Color (for yellow only)
- Yellowness Index (for white only)
- Independent laboratory test results showing the lead and arsenic content of the lot of glass beads used in the thermoplastic formulation (see section 3.4.1 for test methods).

The samples and above information shall be sent to the Transportation Laboratory at the address listed in section 6.4. A Certificate of Compliance (see section 6.1) shall accompany the samples.

Once the Transportation Laboratory approves a lot of thermoplastic, the manufacturer will be notified that the lot/batch is approved for shipment.

When shipments of the approved lots/batches of thermoplastic are made to a Department of Transportation Maintenance facility, the manufacturer shall fax the following information to the Transportation Laboratory within 48 hours of the shipping date. Out of State manufacturers shall also fax the following information to the Transportation Laboratory whenever shipments of approved lots/batches are shipped to warehouses, resellers, or Contractors within the State of California.

- State Specification number (#PTH-02SPRAY (November 2016)).
- A list of each delivery locations and delivery dates.
- Name and phone number of contact person(s) at the delivery location(s).
- Colors, batch/lot numbers and quantity of material comprising shipment.
- Purchase Order number or Contract number and date that order was received.

This information shall be faxed to: Transportation Laboratory, Chemical Testing Section, 5900 Folsom Blvd., Sacramento, CA 95819-0128, attn.: Lisa Dobeck, Fax (916) 227-7168.

4.2 The Department of Transportation reserves the right to take random samples of lots/batches of thermoplastic destined for use by the Department, at the manufacturer's facility. Sampling may also be done at the Contractor's warehouse or jobsite. If requested by the Inspector, batch tickets must also be provided for batches of thermoplastic produced for the Department.

The Department of Transportation also reserves the right to retest any batch/lot of thermoplastic after delivery. Results from such retesting shall prevail over all other tests and will be the basis of rejection. Material not meeting the specification shall be removed and replaced by the supplier at their expense, including all costs for handling, retesting and shipping.

4.3 **Testing:**
All tests shall be performed according to the specified test methods (latest revision) as mentioned in section 3 above. The manufacturer shall maintain a laboratory sufficiently staffed and equipped so as to maintain the quality of the product as called for in these specifications.

5.0 PREPARATION FOR DELIVERY

5.1 **Packaging:**

5.1.1 Block Form:
The thermoplastic material shall be packaged in suitable containers to which it will not adhere nor interact during shipment and storage. The blocks of cast thermoplastic material shall be approximately 900 by 300 by 50 mm and shall weigh approximately 22.7 kg. The containers shall be palletized as specified in the contract or purchase order.

5.1.2 Granular Form:
The thermoplastic material shall be packaged in meltable bags which are compatible with the thermoplastic and which weigh approximately 22.7 kg when filled. The containers must have sufficient strength and be properly sealed to prevent breakage and leakage during normal handling. The bags shall be shrink-wrapped to reduce shifting of the bags on the pallet and shall be palletized as specified in the contract or purchase order.

5.2 **Markings:**
Each individual unit/container of product shall be labeled. This label shall include: State Specification number (#PTH-02SPRAY), color, type of binder, manufacturer's name and address, date of manufacture and batch number. Lead-free yellow materials shall be marked "Lead-Free". All markings on containers shall be legible and permanent. Markings shall not smear or rub off container. Containers failing to meet marking requirements will not be accepted. The containers

and labeling shall meet all applicable US Department of Transportation and Interstate Commerce Commission regulations. Concerning the content, each container shall be labeled with the warnings or precautions required by Local, State and Federal laws and requirements.

6.0 NOTES

6.1 Certificates of Compliance:

The manufacturer of thermoplastic materials shall furnish the Engineer with a Certificate of Compliance in conformance with the provisions of the California Department of Transportation Standard Specifications, 2015, section 6-2.03C, "Certificate of Compliance." The Certificate shall also include a list, by title and section, of all applicable State and Federal packaging and labeling laws and a statement that all requirements have been met. Certificates of Compliance shall be sent along with each delivery of thermoplastic and also with samples sent to the Transportation Laboratory for testing.

6.2 Safety Data Sheets:

The manufacturer shall provide Safety Data Sheets (SDS's) with each delivery of thermoplastic. These SDS's shall include health hazard information on the material when it is heated to application temperature (191°C).

6.3 Patents:

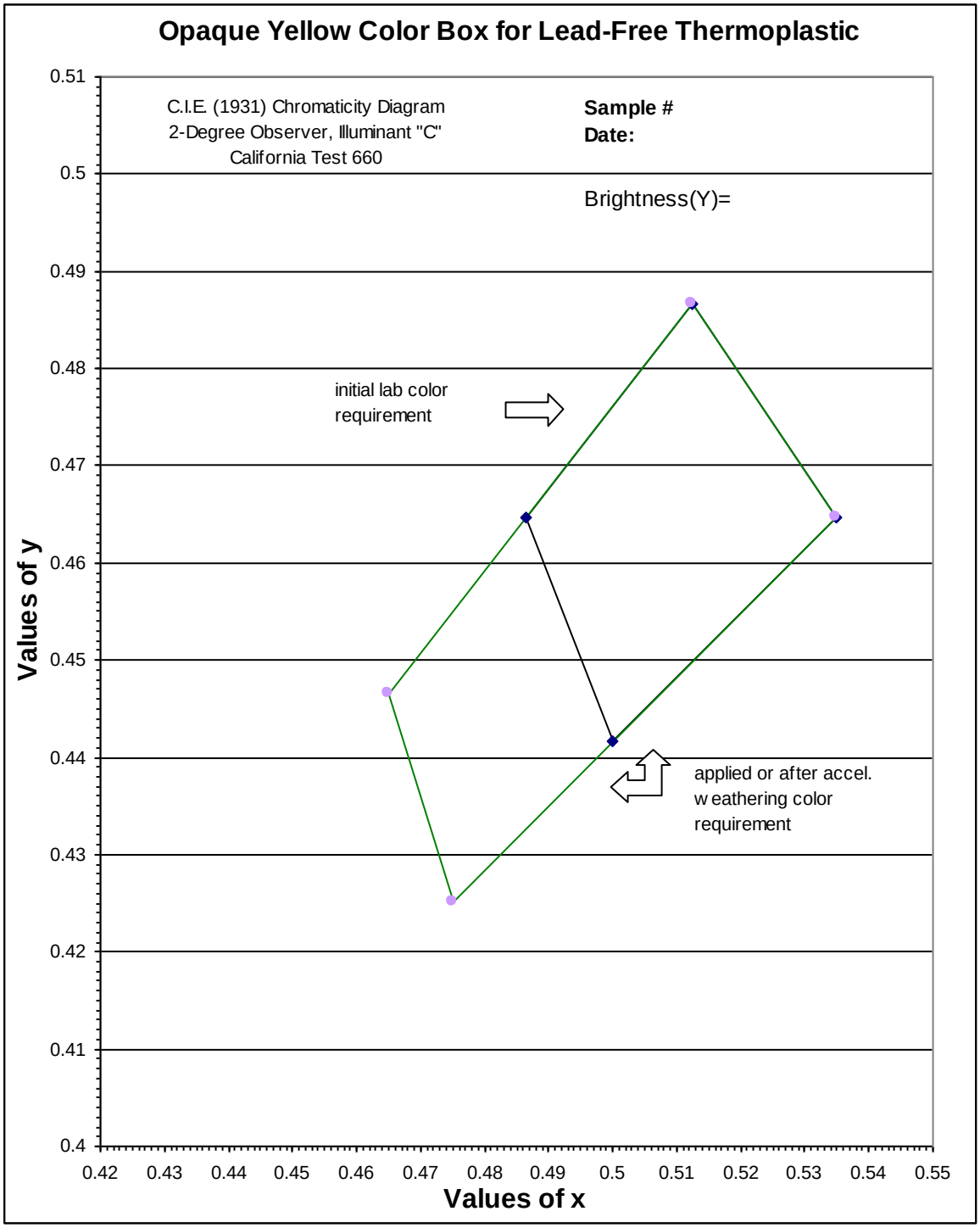
The Contractor shall assume all costs arising from the use of patented; materials, equipment, devices or processes used on or incorporated in the work, and further agrees to indemnify and save harmless the State of California and its duly authorized representatives from all suits at law or action of every nature for or on account of the use of any patented; materials, equipment, devices or processes.

6.4 Contact Information:

Please send samples to the Transportation Laboratory for testing at the address below.

California Department of Transportation
Transportation Laboratory – Chemistry Section
5900 Folsom Blvd.
Sacramento, CA 95819
Attention: Lisa Dobeck
Phone: (916) 227-7291
Fax: (916) 227-7168

CALIFORNIA DEPARTMENT OF TRANSPORTATION
SPECIFICATION #PTH-02SPRAY
(NOVEMBER, 2016)
Filename: SpecPTH-02SPRAY (Nov 2016)


Opaque Yellow Color Box for Lead-Free Thermoplastic
C.I.E. (1931) Chromaticity Diagram
2-Degree Observer, Illuminant "C"
California Test 660
Sample #
Date:
Brightness(Y)=
initial lab color
requirement
applied or after accel.
w eathering color
requirement
Values of y
Values of x
0.51
0.5
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0.4
0.42 0.43 0.44 0.45 0.46 0.47 0.48 0.49 0.5 0.51 0.52 0.53 0.54 0.55